Overview, Geostatistical Temporal/Spatial (GTS) Optimization Algorithm. GTS is a spatial and temporal algorithm for optimizing Long Term Monitoring (LTM) networks using geostatistical methods. AFCEE developed GTS to ensure that only sufficient and necessary monitoring data are captured and analyzed to support decisions crucial to monitoring programs. The algorithm uses a geostatistical method known as "Kriging" to optimize sampling frequency and to define the network of essential sampling locations. AFCEE's algorithm incorporates a decision pathway analysis that is separated into both spatial and temporal (i.e. location and frequency) components. These components integrate the optimization process and assist project managers in cost-effectively managing resources for monitoring both passive sampling networks and those that monitor the performance and/or effectiveness of remedial systems. The algorithm is used to identify spatial and temporal redundancies in existing monitoring networks. Temporal redundancy indicates that a given sampling location is being sampled too frequently. Lengthening the time between sampling events can reduce this redundancy without any significant information loss. Spatial redundancy, which indicates that too many wells are being monitored, can be reduced or eliminated by removing selected wells from the network.

The typical AF installation may have some 100 monitoring wells, and at some bases these monitoring networks can approach 2000 wells. The Air-Force wide monitoring inventory is estimated to be over 20,000 wells or 20,000 potential sampling locations. Sampling individual monitoring wells, including costs associated with mobilization, lab analysis, QA/QC, reporting, data management, and the like, is an expensive endeavor. A typical installation having 100 wells, may pay $1500 per well or a total of $150K for a single sampling round. And corporately across the AF, these expenses could amount to an estimated $30M, assuming that the entire monitoring network of all wells were sampled only once during a single global monitoring event. In reality of course, monitoring wells are more likely to be sampled repetitively over future years until remediation has been proven to be effective and sites are closed---------often over decades. Thus in its entirety, the Air-Force wide monitoring program, even with a minimal effort, could easily exceed $30M over an uncertain period of out-years. The intent of using GTS is to benefit from a clear opportunity to reduce these sampling efforts through an optimized monitoring approach. Examples at AF installations and DOE industrial facilities suggest that sampling budgets can be reduced 30-40% by using optimization techniques. For an Air-Force wide monitoring program, cost avoidances in the tens of millions of dollars could easily be realized. GTS is a site-specific technique (the optimized solution is unique to the site), but a significant amount of data is required to employ the techniques. The typical application scenario for applying GTS are sites that have 40 or more monitoring wells and sufficient sampling data. Time series data should span at least four quarters to account for seasonality and sample sizes should ideally exceed 8 events per well. Other necessary information includes: coordinate data, well construction details (such as screen settings with depth), aquifer characteristics, water levels, and the like. Electronic data management is a significant component to the overall optimization effort, and perhaps 80% of the effort can be consumed merely by assembling a quality data set for the geostatistical analysis. The standard electronic data structure recommended is the AF's Environmental Resources Program Information

Management System or ERPIMS. Lastly and perhaps more importantly, application of the GTS algorithm requires an expert geostatistician along with standard, commercially available off-the-shelf statistical and geostatistical software. Depending on site complexities and the number of sampling locations, the labor to perform the expert geostatistical analysis using GTS can take approximately one man-month.

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